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ABSTRACT

A mathematics pedagogy course was developed and co-taught by mathematics and mathematics education faculty to 22 teaching assistants (TAs) in the mathematics department. Its purpose was to allow TAs to examine their beliefs about the teaching and learning of mathematics and to support them in changing their teaching practice. The course consisted of 5 seminar classes addressing issues surrounding pedagogy, epistemology, curriculum, and assessment. Throughout the course the TAs were asked to implement changes in their teaching based on class activities and discussion and to document their reflections on these changes, which served as the basis for subsequent class discussions. Journal entries, class assignments, interviews, and teaching observations served as sources for data and were analyzed using descriptive statistics and techniques from qualitative analysis. Results indicated that the TAs appeared to adopt a new set of beliefs regarding the teaching and learning of mathematics yet did not draw on these beliefs to inform their teaching practices. These results are presented and discussed in the context of research on beliefs and recommendations for the pedagogical preparation of TAs are offered. (Author)

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THE BELIEFS AND INSTRUCTIONAL PRACTICES OF MATHEMATICS TEACHING ASSISTANTS PARTICIPATING IN A MATHEMATICS PEDAGOGY COURSE

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Abstract: A mathematics pedagogy course was developed and co-taught by mathematics and mathematics education faculty to 22 teaching assistants (TAs) in the mathematics department. Its purpose was to allow TAs to examine their beliefs about the teaching and learning of mathematics and to support them in changing their teaching practice. The course consisted of 5 seminar classes addressing issues surrounding pedagogy, epistemology, curriculum, and assessment. Throughout the course the TAs were asked to implement changes in their teaching based on class activities and discussion and to document their reflections on these changes, which served as the basis for subsequent class discussions. Journal entries, class assignments, interviews, and teaching observations served as sources for data and were analyzed using descriptive statistics and techniques from qualitative analysis. Results indicated that the TAs appeared to adopt a new set of beliefs regarding the teaching and learning of mathematics yet did not draw on these beliefs to inform their teaching practices. These results are presented and discussed in the context of research on beliefs and recommendations for the pedagogical preparation of TAs are offered.

Introduction

As early as the late 1800s, universities offered graduate teaching assistantships to attract students to graduate studies. However, by the end of World War II, colleges and universities expected graduate teaching assistants (TAs) to assume other responsibilities, such as grading and teaching (Hendrix, 1995). Today, TAs play a vital role in the day-to-day activities of university life and carry a considerable portion of the teaching load among two-and four-year colleges and universities. Further, it is projected that half a million new professors will be needed by the year 2014 (Baiocco & DeWaters, 1998) thus increasing the likelihood that TAs will continue to be an integral part of the teaching fabric of colleges and universities in the near future.

As the number of graduate students teaching college courses has increased, the adequacy of their preparation to teach such courses has come into question (Hammrich & Armstrong, 1995; Carroll, 1980). To remedy this situation, a number of universities have developed training programs or courses for TAs in disciplines, such as mathematics (National Advisory Group of Sigma Xi, 1989; Wagener, 1991; Hammrich & Arm-

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strong, 1995; Damarin & West, 1979) and in areas such as, instructional strategies, learning styles, communication skills, undergraduate student needs, and issues specific to international teaching assistants (Enerson, 1996; Nyquist & Wulff, 1986; Travers, 1986; Wright, 1981; Damarin & West, 1979).

In spite of university efforts to prepare TAs to meet the challenges of teaching, research has found that TAs believe universities provide limited support in helping to prepare them to teach at the college or university level. Further, research (Monaghan, 1989) has indicated that many TAs have little or no prior instruction in pedagogical theory or experience in teaching and rely primarily on models of teaching they have experienced as students.

As a result of these issues, a one-credit mathematics pedagogy course was developed and co-taught (by mathematicians and mathematics educators) to the TAs in the mathematics department. Its goal was to provide an opportunity for the teaching assistants to examine their beliefs about teaching and learning mathematics and alter their teaching practice. The purpose of this study was to examine the nature of the TAs' beliefs as they progressed through this mathematics pedagogy course and to describe the constraints they faced in trying to make changes in their teaching practices.

Background of the Study

The study of teachers' beliefs and its impact on teaching and learning is relatively new (Thompson, 1992). However, a number of studies in mathematics education have found that teachers' beliefs about mathematics and the teaching and learning of mathematics play a significant role in shaping characteristic patterns of instructional behavior (Thompson, 1992). Ernest (1988) noted that among the factors that influence the practice of teaching mathematics, three are most notable: (1) the *social context* of the teaching situation, particularly the constraints and opportunities it provides; (2) the teacher's mental contents or schemas, particularly the *system of beliefs* concerning mathematics and its teaching and learning; and (3) the teacher's level of thought processes and *reflection*.

It is clear that the *social context* in which an individual teaches significantly shapes one's understanding of teaching and may provide constraints and opportunities for changing one's practice. As noted by Schoenfeld (1992), "the habits and dispositions of community members are culturally defined and have great weight in shaping individual behavior" (p. 340). The day-to-day routines and norms of classrooms and schools provide a cultural milieu in which individuals acquire a point of view with respect to the teaching and learning of mathematics. In a similar way, by virtue of their participation (i.e., as a student, teacher, and colleague) in the daily routines of university life and mathematics departments, TAs' view of the discipline and their instructional practices are shaped.

Some researchers (Green, 1971; Rokeach, 1964) have used the notion of a *belief system* as a metaphor, to describe the organizational structure of beliefs acquired by an

individual. In this view, belief systems are dynamic and subject to change (Thompson, 1992) and may help explain certain behavior with respect to teaching and learning. Green (1971) has identified three dimensions of belief systems—a quasi-logical structure, the psychological strength between beliefs, and the clustering nature of beliefs. The quasi-logical structure of a belief system permits beliefs to be "primary' (e.g., a belief that is used as a reason for other beliefs) or "derivative" (e.g., a belief derived from some other belief). The notion of which beliefs are most important, and thereby more resistant to change, has to do with the strength in which these beliefs are held. Psychologically "central", or "core", beliefs are held with greatest conviction and are least susceptible to change while "peripherally" held beliefs are more likely to be altered or changed. Finally, the third dimension of the belief system indicates that beliefs are held in "clusters" and generally in isolation from other clusters (Green, 1971).

In the mathematics education literature, there is an extensive body of research on teacher's beliefs about mathematics and mathematics teaching and learning. In particular, research indicates that the beliefs held by teachers can have profound, though possibly subtle effects on their mathematics teaching (Thompson, 1984; Peterson, Fennema, Carpenter, & Loef , 1989). Researchers (Brown, Cooney, & Jones, 1990) have found that preservice teachers hold core beliefs regarding the teaching and learning of mathematics prior to formal teacher preparation coursework. Further, these beliefs may hinder one's ability to align teaching practices with current reform efforts in mathematics education (Frykholm & Brendefur, 1997).

Together, the notion of the social context of the university and mathematics department, as well as the belief systems of the TAs, provided a foundation to examine the TAs' understanding of the teaching and learning of mathematics and their classroom practice.

Research Questions

1. To what extent and in what ways did the mathematics pedagogy course lead to changes in TAs' beliefs about mathematics and mathematics teaching and learning?
2. What factors help explain the nature of the TAs' classroom practice?

Methods and Procedures

This study employed qualitative techniques to examine the teaching assistants' beliefs and instructional practices. A description of the mathematics pedagogy course and participants in the study follows next.

Mathematics Pedagogy Course

The mathematics pedagogy course is offered through the mathematics department and is a requirement for new TAs in the department. The course is organized around

five seminar-style class sessions, each two and one half-hours long, beginning in mid-September and ending in mid-November. This past year 2 faculty members from the mathematics department, 2 faculty members from the Neag School of Education, and 22 TAs attended class regularly. Classroom activities modeled a constructivist perspective of learning and assignments in-and out-of class encouraged the TAs to discuss and reflect on ideas about teaching and ways to change and improve their teaching practice. Typically, classroom sessions involved a cyclical process of class activities/discussion—classroom teaching—reflection that provided a support structure to help the TAs reflect on their beliefs about mathematics and teaching and implement changes in the classes they were teaching.

Participants

The Mathematics Department

At the time of the study, the mathematics department consisted of 30 full-time faculty and 3 adjuncts. With the help of the TAs, the department offers and teaches undergraduate and graduate mathematics courses and services a number of academic departments in the university. Being a Carnegie I Research institution, faculty believe their mission is to conduct research and publish their results within their respective mathematical fields. Normally, senior faculty members in the department teach upper division courses while junior faculty and TAs are assigned to teach the lower division courses. Also, senior faculty members are assigned to monitor and oversee the curriculum and the testing of remedial-level courses. Most instruction tends to model a transmission method of teaching. In recent years there has been shift in the culture of the department and an emphasis has been placed on curricula reform and improving classroom instruction.

The Teaching Assistants

There were 22 teaching assistants who participated in the mathematics pedagogy course. These students were either enrolled in Masters or Ph.D. programs in Mathematics and were supported by teaching assistantships. As part of their assistantship, TAs taught two remedial-level mathematics courses each semester. The TAs came from various backgrounds and cultures—for example, at the time of this study, there were TAs from a dozen countries in the mathematics department. In general, the TAs have acquired a view of the discipline and a view of teaching based on their own academic experiences. Further, they have had no formal training in teaching and lack an understanding of learning theory, curriculum, or assessment.

Data Collection and Analysis

Several sources of data were collected throughout the study, including interviews, journal entries, questionnaires, and classroom observations. For example, prior to the start of the mathematics pedagogy class each TA participated in an interview regard-

ing their views about mathematics and the teaching and learning of mathematics. In addition, throughout the semester, the TAs kept a reflexive journal about their teaching experiences. During each pedagogy class the TAs were also asked to respond individually to a series of open-ended questions about issues related to topics discussed in class that day. Finally, during the months of November and December faculty members associated with the mathematics pedagogy course observed a lesson taught by the TAs. This lesson was videotaped and the TAs were asked to review the tape and respond to several questions about the lesson and their teaching performance. In addition to completing these questionnaires, several TAs participated in follow-up interviews. Qualitative techniques were employed to analyze the data. In particular, all of the interviews were transcribed and coded, and a cross-case analysis was used to identify themes and patterns with respect to TAs views about mathematics teaching and learning prior to the mathematics pedagogy course. In addition, data from journals, questionnaires, and observation notes, were reviewed for themes and organized in partially-ordered meta matrices (Miles & Huberman, 1994) to capture changes in the TAs' beliefs and practices during the course of the semester.

Results and Discussion

In order to answer research question 1, information regarding the TAs' beliefs prior to and after the mathematics pedagogy course was collected, analyzed, and reported next.

TAs' Initial Beliefs About Mathematics and the Teaching and Learning of Mathematics

It was apparent that prior to the mathematics pedagogy course the TAs had acquired a belief system about mathematics teaching and learning consistent with that of novice teachers and relying primarily on models of teaching they had experienced as students. In general, the TAs indicated they believed "being knowledgeable" was the principal attribute of effective teachers and that the act of teaching involved "giving knowledge to students". This view of teaching (i.e., transmission model) was also evident in the TAs' description of their instructional style—in every case the TAs described a teacher-directed approach that involved very little, if any, classroom discussion. Further, when asked whether they used small-group work in class, many TAs stated they encouraged their students to work together on assignments outside of class and as a means to review for a test, but generally believed that students learned mathematics by solving problems on their own. Finally, when asked to describe their understanding of how students learn mathematics the TAs provided a naïve perspective that included: "students learn in different ways", students learn by reading the textbook and reviewing their notes", and "students learn by memorizing information." What impact did the course have on their beliefs?

Impact of Mathematics Pedagogy Course

In general, the TAs indicated that the mathematics pedagogy course played a significant role in challenging their long-held beliefs about the teaching and learning of mathematics. For example several TAs commented they now understood that the goal of teaching was to promote an understanding of the material rather than "getting through the material and having students memorize and regurgitate" information. The TAs also mentioned that the course helped them to understand the difference between teaching and telling. Finally, several TAs described how class activities and discussions with other TAs and journal writing assignments caused them to be more reflective about their teaching practices and more willing to take risks in trying different approaches to teaching.

One activity that appeared to have a significant impact on the TAs' beliefs regarding the way students learn occurred after watching an excerpt of the video, *A Private Universe* (Schneps & Sadler, 1992). This video explores the nature of misconceptions that students bring and hold on to in a learning situation. After the video, the class discussed several theories of learning, including constructivism. As part of the class activities and subsequent journal entries, the TAs described their understanding of how students come to know mathematics and how this information might inform their teaching. For example, a number of the TAs indicated that students learn mathematics by "fitting in" or assimilating new information into pre-existing knowledge structures. They also recognized that students' prior knowledge might contain misconceptions, which may influence their learning. Teaching strategies outlined by the TAs to support a constructivist epistemology included allowing students to work on problems in class to uncover misconceptions about mathematics and using examples/counterexamples to challenge students' misconceptions. In addition, the TAs suggested that technology, visual aids, and varying the mode of instruction might provide for more effective instruction and increase student understanding of the material.

At the end of the mathematics pedagogy class it became evident that the TAs had acquired a different set of beliefs regarding the teaching and learning of mathematics. So what impact did this have on their classroom practice? In order to answer this question (i.e., research question 2) data from classroom observations, journal entries, and class assignments were analyzed and discussed below.

Factors that Explain the TAs' Classroom Practice

Classroom observations of the TAs at the end of the mathematics pedagogy course revealed classroom instruction that was largely teacher-directed (i.e., transmission model) and involved very little, if any, student-student or teacher-student interactions. Analysis of the data indicated that the background and experience of the TAs and the cultural norms of the university and the mathematics department provided a lens to examine and understand the TAs' classroom practice.

Over the years, the TAs have been enculturated into the field of mathematics (i.e., as students learning mathematics) and teaching (i.e., models of teaching they have observed) by virtue of their participation in the day-to-day routines of their past and present school experiences. It is clear that these experiences, in addition to their lack of pedagogical training, helped shape their teaching behavior. Further, since many of the TAs planned to pursue careers in actuarial science or at research institutions, teaching did not appear to be a high priority. In addition, the international teaching assistants' (ITA) perceived marked differences between the American educational system and schools in their native countries with respect to the role of students and teachers. For example, many ITAs' expressed difficulty in making eye contact with students and getting students to come to class and complete homework, while most TAs' expressed difficulty in questioning students and viewed the role of the teacher as the central authority figure in class.

The cultural norms of the mathematics department and the university provided a milieu, which further shaped the TAs' point of view with respect to the teaching and learning of mathematics. For example, all of the TAs were expected to follow demanding and rigid common course syllabi, which were designed by senior faculty members in the mathematics department. As a result, many of the TAs' viewed teaching as "covering the material" rather than promoting student understanding. Further, by virtue of being a Carnegie I Research institution, research is valued and rewarded. Faculty in the mathematics department viewed their primary role as publishing their research and these values were communicated to the TAs through daily interactions.

This study revealed that although the TAs adopted a new set of beliefs about the teaching and learning of mathematics their classroom practices remained the same. Research on belief systems (Green, 1971) provided a plausible explanation for why the TAs did not draw upon their newly acquired beliefs in changing their classroom instruction. In particular, the clustered nature of beliefs and the fact that individuals hold core and peripheral beliefs implies that beliefs may be held in conflict and that certain beliefs are more strongly held, and perhaps acted on, than other beliefs. As Thompson (1992) noted, a teacher may feel it is more important (i.e., a central belief) to answer student questions for reasons of maintaining authority and credibility than for clarifying the subject to students (i.e., a peripheral belief). In this study, it appeared that the newly acquired beliefs adopted by the TAs were peripheral and held in conflict to their core beliefs about the teaching and learning of mathematics. For example, although the TAs indicated a new understanding of how students learn mathematics (i.e., by actively constructing knowledge) this belief seemed to be held peripherally and in conflict with their views about the role of teachers (i.e., to deliver information or as the central authority figure in class). In the end, the TAs appeared to rely on their central beliefs about the teaching and learning of mathematics in defining their teaching practices.

In this study, it appeared that university and departmental norms validated the TAs' instructional behavior. For example, the TAs' ability to keep up with common course syllabi and prepare their students for the common exams was viewed by the TAs as evidence that they were being effective teachers. Further, as the cultural norms of the university and mathematics department helped validate the TAs' teaching practice, they may have also acted as barriers, preventing the TAs from becoming dissatisfied with their teaching, a prerequisite for initiating innovation as described in change process models (Edwards, 1994; Evans, 1996).

Final Remarks

This study sought to understand the nature of TAs' beliefs about mathematics and the teaching and learning of mathematics and their teaching practice. The results indicated although the TAs adopted new sets of beliefs regarding the teaching and learning of mathematics, their teaching practice remained unaltered. So what have we learned from this study regarding ways to help TAs become more effective teachers?

- Mathematics pedagogy courses must be viewed as ongoing professional development experiences that support TAs through the long and complex process of changing their teaching practice. It is important that such courses be collaborative efforts designed and taught by both mathematics and education faculty.
- Such courses should create opportunities for TAs to become dissatisfied with their practice by incorporating activities that challenge their firmly held beliefs about mathematics and the teaching and learning of mathematics.
- Further, mathematics pedagogy courses must help TAs acquire the skills necessary to carry out innovations in their teaching. To do so, effective models of teaching, critical reflection, and discussion must be central components of the course.
- Finally, there needs to be a shift in the cultural norms of universities and mathematics departments—institutionally, faculty must begin to see how research can inform one's teaching and engage TAs' in discussions about pedagogical matters.

We believe that through this process, mathematicians and mathematics educators can work collaboratively to improve the pedagogical preparation of TAs.

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